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An Integrated Lean Service and Machine Learning Approach to Improve On-Time Delivery in a SME Restaurant

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***Abstract*— Food service establishments operate in environments where demand variability, ingredient availability, and delivery speed affect operational performance. In this context, a diagnostic assessment conducted in a pizza restaurant identified inefficiencies such as inventory inaccuracy because of insufficient supplies, inefficient mise in place due to long search times, and unproductive time related to process control and layout design. To address these main issues, this study proposes an integrated model that applies a Random Forest algorithm to forecast weekly demand and synchronizes purchasing and production using an EOQ-MRP system supported by Kanban as a visual control mechanism, in addition, standardized work and workstation redesign are implemented to reduce preparation time. The proposed model improves demand forecasting and enables better inventory planning and coordination between purchasing and preparation activities. Hybrid validation shows an increase in process compliance from 79% to 97% after implementation. These findings indicate that integrating Machine Learning forecasting with Lean Service tools process synchronization between all the processes and stabilizes ingredient supply, enhancing operational performance in foodservice environments. These results open the path for future research integrating predictive analytics with Lean Service methodologies to address operational variability in dynamic foodservice settings.**

Keywords*— Lean Service, Restaurant, Machine Learning, Kanban, Standardized Work.

I. INTRODUCTION

Globally, the foodservice sector plays a key role in the global economy, with a market size of US$3,089 billion in 2024 and a projected CAGR of 3.15% toward 2033 [1]. In Latin America, gastronomy represents approximately 30% of international tourism spending [2], although the sector faces challenges such as informality, volatile input costs, and limited digitalization [3].

In Peru, the hotel and restaurant sector represented 2.5% of the national GDP in 2024, confirming its importance for consumption and tourism, while also exposing limitations related to rising costs [4][5].

In this context, industrial engineering approaches are required to improve synchronization and efficiency in restaurant operations. This study analyzes a pizza restaurant in Lima facing significant delivery delays and inventory management errors due to inaccurate demand forecasting and uncoordinated replenishment cycles. To overcome these issues, a Lean Service model integrating Machine Learning forecasting (Random Forest), inventory optimization (EOQ/ROP), and MRP-based production planning, supported by Kanban, is proposed to improve On-Time Delivery and operational performance.

II. STATE OF THE ART

A. *On-Time Deliveries in the Restaurant Sector*

Timely delivery of orders is a key challenge in the restaurant industry, affecting service quality and operational efficiency. The post-pandemic context increased competition in food delivery services, requiring process optimization and reduced lead times without affecting quality and food safety [6]. However, low productivity remains a constraint that generates losses and customer dissatisfaction [7].

B. *Supply Management focused on machine learning*

The application of demand forecasting models significantly improves on-time delivery in the food sector. Machine learning techniques like Random Forest and LSTM reduce waste by 52% and enhance order fulfillment by 16% [8]. Similarly, predictive models decrease errors in perishable products (RMSE = 27.82; MAE = 20.63) [9] and increase OTIF by 51.42% while reducing total order cycle by 75.98% when combined with Lean practices [10].

C. *Time Optimization Through the Implementation of Kanban*

The implementation of Kanban reports a 13% increase in production, a 13.5% increase in value-added activities, and up to a 12% improvement in production times after applying this tool. Additionally, [11] found that the Kanban system can help lower inventory levels and reduce search time, achieving an improvement of up to 46%. Likewise, [12] achieved a 13.46% increase in productivity by improving workflow management. Methodologically, this tool emphasizes task prioritization, workflow clarity, and delivery deadlines [13]. Furthermore, [14] demonstrated that their application can reduce value-added time by up to 50% with optimized Kanban models.

D. *Improving On-Time Deliveries through Standardized Work*

The implementation of Standardized Work reduced total process time from 50 to 30 minutes (−33.12%), improving delivery performance by 29.18%. Likewise,[15] reported a 17.31% reduction in total processing time and a 95.74% on-time completion rate for finished products. Hybrid validation confirmed that combining Lean Service and Work Study techniques in fast-food processes reduced delivery time by 31.26% and increased productivity by 47.43%, leading to better operational efficiency and lower waste.

E. Lean Service applied to On-Time Delivery

The application of Lean Service in the food sector increased productivity by 18% and efficiency by 27% [16] reduced service cycle from 35 to 27.36 minutes, and improved customer satisfaction by 26.39% [17]. Combined with Kanban, main process cycle times reduced by 19% in SMEs [12]. Additionally, a poorly optimized layout accounted for 57.8% of unproductive time due to unnecessary movements. Ergonomic workstation redesign and standardized work can minimize these inefficiencies. Layout optimization in the food industry improved on-time delivery from 41% to 82.78% and reduced movement time by 29% [7]. Integrating anthropometric design with standardized work increased productivity by 19.83% and reduced postural risk by 54% [18].

III. CONTRIBUTION

Restaurants operations are affected by poor supply planning, internal replenishments inconsistencies and high variability in manual processes [17, 19, 20]. To prevent the many gaps that hinder the workflow of complex environments such as food services, the integration of Lean tools is required [14]. In this context, the combination of Lean Service, supply management, and Kanban pull systems stabilizes internal workflows and improves service performance. In addition, Machine Learning supports production planning by adapting to demand variability and reducing lead times [7]. For instance, Random Forest models provide accurate demand forecasts in dynamic environments such as restaurants, where consumption varies by time and season [9]. These forecasts support decisions related to inventory policies, Master Production Scheduling (MPS), and Material Requirements Planning (MRP), which are essential for ensuring ingredient availability [20]. In Additionally, the ergonomic design of workstations plays a critical role in task execution and preparation time. Studies have shown that redesigning stations based on ergonomic criteria improves posture, reduces fatigue, and increases speed and precision in manual processes [16, 18]. In this research, ergonomic improvements were validated using DELMIA simulation software and RULA analysis, which confirmed the positive impact of station redesign on service times.

In this context, the proposed model in Figure 1 serves as the framework that synchronizes such operational optimizations with predictive accuracy. By leveraging a Random Forest algorithm, the system generates high-fidelity forecasts for Supply Management (EOQ, ROP, and MRP), which are then translated into physical actions via Kanban and Standardized Work. This mediation transforms statistical precision into measurable gains, achieving a 97% On-Time Delivery rate and a 60.8% reduction in stockouts. The model follows the Plan-Do-Check-Act (PDCA) cycle, a proven method for guiding continuous improvement in service operations [16, 19].

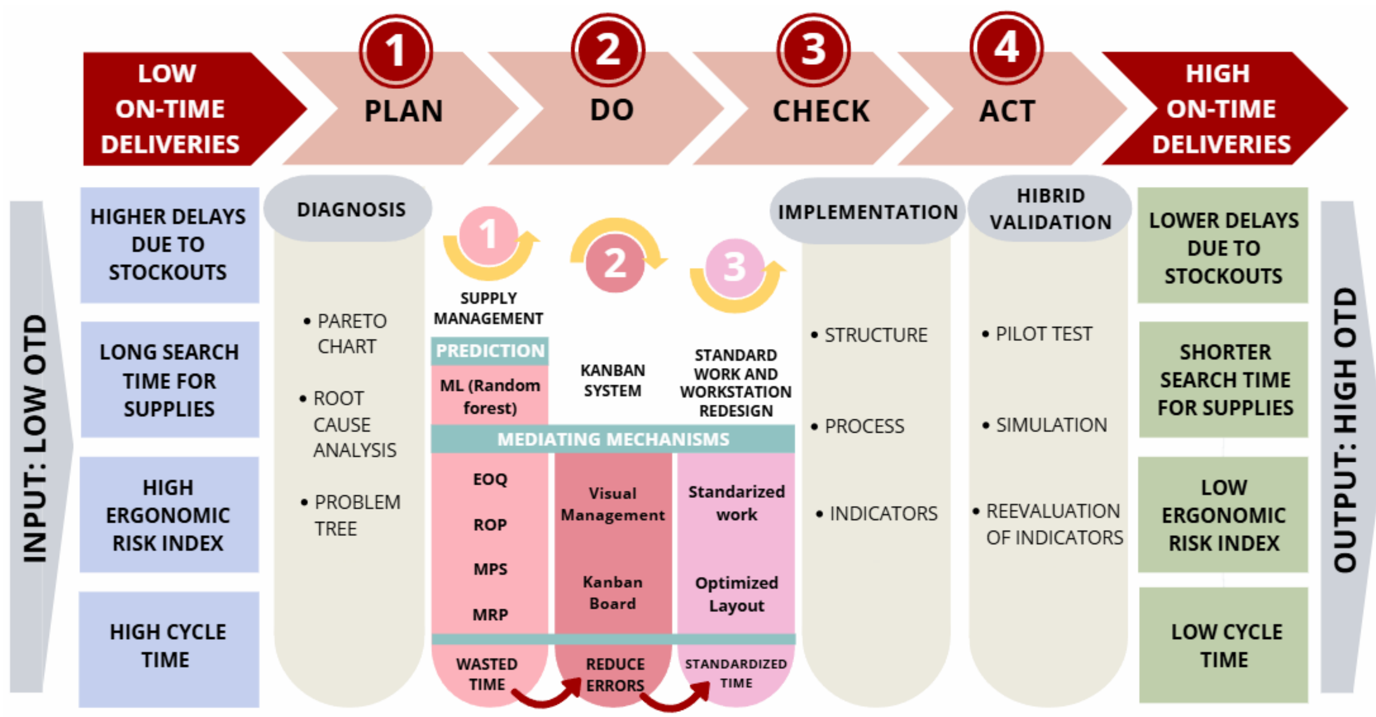

Fig. 1. Proposed Model

A. Phase I: Plan

In the Plan phase, the main problems affecting On-Time Delivery were identified through tools such as the problem tree and cause-effect diagram. Key issues included inventory inaccuracy, inefficient mise in place, and unproductive time. These were prioritized based on performance indicators like stockout rate, search time, and cycle time compliance

B. Phase II: Do

This phase implements Supply Management, Kanban, and Standardized Work to optimize material flow, inventory control, and process efficiency. Demand forecasting, consumption analysis, and lead time evaluation are used to define reorder points and purchasing frequency, reduce shortages and ensure ingredients availability. A Kanban replenishment to stabilize the internal supply flow and reduce search time, preventing stockouts. Additionally, the pizza assembly workstation is reorganized according to frequency of use and sequence of operations, and a standard work routine is established for dough handling, sauce application, cheese allocation, ingredient distribution, and oven loading. Standardization has been shown to reduce cycle time variability and operational errors in similar environments [16, 17]. Ergonomic validation was conducted using DELMIA and RULA tools [21].

C. Phase III: Check

In this phase, key indicators were used to measure the impact of each component of the proposed model. First, On-Time Delivery measures the percentage of orders delivered on time, reflecting service reliability. In this case, the benchmark sector is 90% [20], while the case study reports a current performance of 79.1%, revealing a significant gap to be addressed.

TABLE I. INDICATORS

Indicators	Formula
On-time delivery	$\frac{\textbf{On time Deliveries}}{\textbf{Total Orders}}\ x\ 100$
Stock Out	$\frac{\textbf{Unfulfilled Demand}}{\textbf{Total Demand}}\ x\ 100$
Replenishment time	$\sum \textbf{Supply replenishment time}$
Compliance with the standard process time	$\frac{\textbf{Processes within standard time}}{\textbf{Total Processes}}\ x100$
Cycle time in Movements	$\sum \textbf{Time in movements}$

D. Phase IV: Act

In the Act phase, the most effective actions were integrated into the restaurant's daily operations. This ensured that these improvements could be used anytime and serve as a base for future optimization efforts. This structured approach addressed the restaurant's most critical operational gaps by refining the implemented tools based on pilot results.

The simulation validates the system's behavior under realistic demand conditions, identifying residual bottlenecks and confirming the expected performance benefits, as recommended in Lean simulation-based validation studies [21]. Final adjustments are incorporated into updated standards, Kanban triggers, and workstation layouts to ensure long-term.

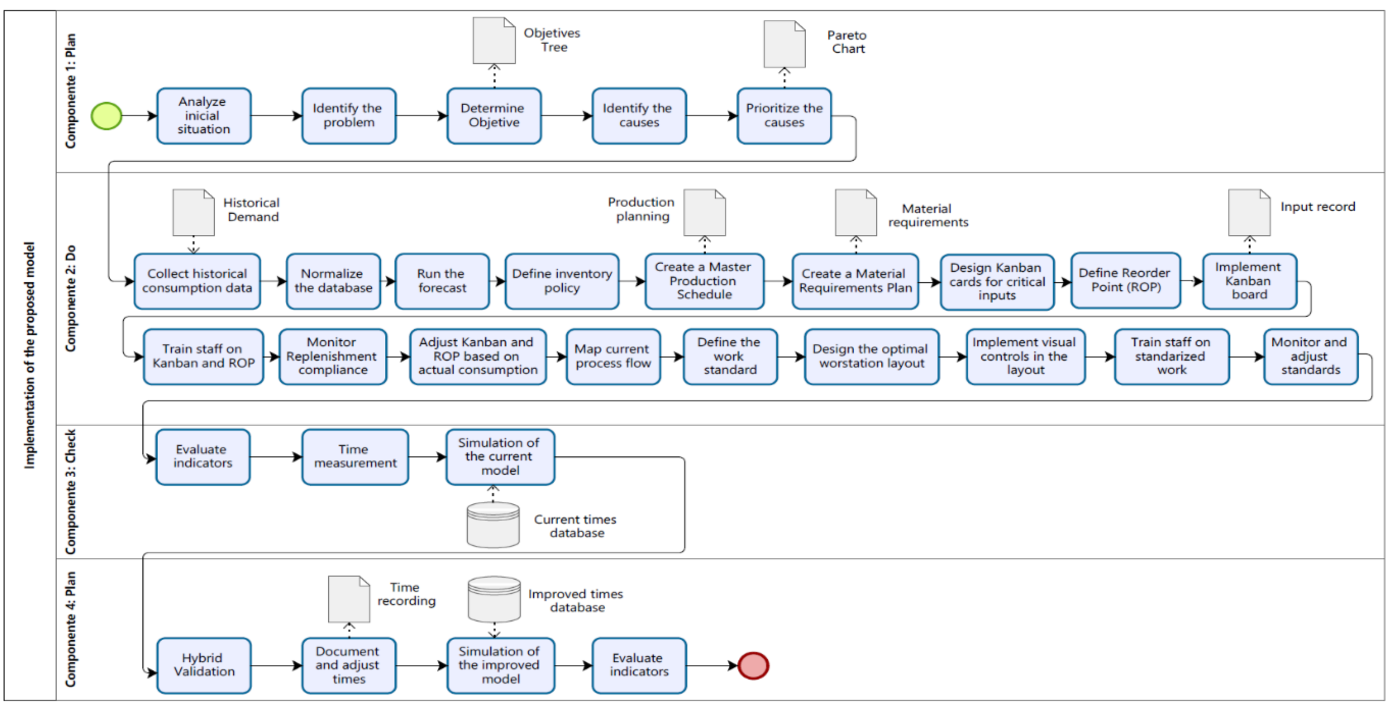

Fig. 2. Diagram of the proposed model

IV. RESULTS

The proposed improvement model was implemented in two phases. First, a five-week pilot intervention that was carried out in the kitchen and supply areas to test the effectiveness of Lean tools and predictive planning in a real environment. Next, the adjusted process was simulated under variable demand conditions to evaluate its impact on key indicators such as on-time delivery, preparation time, stockouts, average replenishment time, compliance with standard process times, and cycle time in movements.

A. Initial diagnostic

This technique was used because similar solutions have been evaluated in the past by other authors [16] in food production and operations environments. Its use is suitable for this study because the process is repetitive, highly time-sensitive, subject to variable demand, and direct intervention could risk reducing service quality.

The diagnosis identified inventory inaccuracy, inefficient mise en place, and unproductive time in the assembly process. These issues reduced production stability and service reliability, with an on-time delivery rate of 79.1%. The economic impact reached 39,798 PEN due to overtime, material waste, and reprocessing.

A detailed analysis of operational indicators enabled the identification of key root causes included insufficient supply levels (26.15%), long search times (26.03%), low adherence to standardized processes (24.51%), and inefficient layout (23.31%). These factors disrupted production flow and affected delivery performance.

B. *Validation methodology*

The family-size Pepperoni pizza was selected as the target product for demand forecasting, as it is the best-selling item, representing 28% of total pizza sales. This makes it a suitable reference for evaluating forecasting models. To assess predictive performance, two models were developed in Python: Holt-Winters and Random Forest.

The predictive component was developed using a Random Forest regressor architected to capture non-linear dependencies within a robust dataset of 116 weekly demand observations. To ensure the model's reliability in a real-world restaurant environment, a temporal, non-random split was implemented to preserve causal integrity and prevent data leakage, designating the final 12 weeks for rigorous backtesting. The architecture utilizes an ensemble of 200 decision trees to minimize variance and enhance generalization capabilities. Feature engineering focused on high-relevance multi-dimensional predictors, including time trends, seasonal indicators (week of the year and month), and marketing-driven signals, alongside autoregressive components such as lags and a 3-week rolling mean. Finally, model performance was validated through a walk-forward validation approach, simulating periodic updates and ensuring the stability of the 2.6% MAPE achieved.

Accuracy was measured using Mean Absolute Deviation (MAD), Root Mean Square Error (RMSE), Mean Absolute Percentage Error (MAPE), Weighted MAPE (WMAPE), and Bias. As shown in Table 2, the Random Forest model outperformed Holt-Winters, achieving lower error rates in all metrics, including a superior 2.6% MAPE. Figure 3 presents the 12-week demand forecast, where Random Forest demonstrates more stable and accurate predictions, supporting improved inventory decisions.

TABLE II. EVALUATION OF FORECASTING MODELS

Model	MAD	RMSE	MAPE%	WMAPE%	BIAS%
Random Forest	11.38	13.06	2.6	2.62	-2.62
Holt-Winters	13.61	16.99	3.15	3.14	0.47

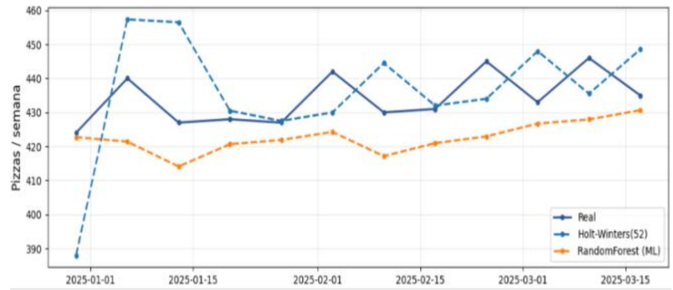

Fig. 3. Model performance comparison

To improve inventory management and production planning, an integrated approach was implemented, combining key tools such as Economic Order Quantity (EOQ), Reorder Point (ROP), Safety Stock, Master Production Scheduling (MPS), and Material Requirements Planning (MRP). The EOQ model helped determine optimal order quantities, while reorder points established the minimum inventory levels needed to trigger replenishment, ensuring a consistent supply and operational continuity.

To validate the proposed model and assess its performance, a discrete event simulation was developed in Arena software. The simulation ran over a 60-day period with 8-hour workdays and included 28 replications to ensure statistical accuracy. This sample size enabled the computation of 95% confidence intervals using t-student distribution to account for stochastic variability between runs.

The simulation results show a clear improvement in inventory behavior. In the initial scenario, inventory levels were irregular with frequent fluctuations caused by unstructured replenishment practices. After implementing EOQ and planning tools, inventory becomes more stable, structured and predictable.

In the improved scenario, the inventory patterns follow a more consistent cycle that reflects the weekly demand of key raw materials. For instance, high-demand items like flour (around 252 kg per week) and cheese (112 kg per week) reach higher inventory levels and take longer to deplete. This is expected, as their consumption justifies larger and less frequent replenishment batches.

On the other hand, moderately consumed ingredients such as pepperoni (56 kg per week) and tomatoes (42 kg per week) show smaller and more frequent cycles. Their lower demand leads to reduced inventory peaks and smoother restocking patterns. Additionally, the use of safety stock prevents inventory levels from dropping to zero, helping stabilize the system and ensuring a more consistent and efficient operation overall.

Following the simulation and demand forecasting results, a visual management system based on Kanban was implemented to improve ingredient replenishment during the pizza preparation process. The simulation identified delays related to ingredient unavailability in the workflow. To address this issue, a Kanban system was introduced to support inventory and replenishment parameters. The implementation of Kanban reduced average replenishment time from 10 minutes to 1.5 minutes. This improvement was achieved by reducing waiting time, overproduction, and unnecessary movement, while ensuring material availability [11]. As a result, the workflow improved during high-demand periods.

A physical Kanban pilot was conducted over five consecutive weekends within the kitchen environment. Color-coded cards were attached to containers of high-rotation ingredients such as sauce, cheese, and pepperoni. These cards were also placed on a central board organized into three sections: "To Do," "In Progress," and "Done" (Figure 4). This visual arrangement enabled real-time tracking of inventory levels and allowed staff to identify and respond promptly to replenishment needs without interrupting the production flow.

Fig. 4. Pilot Kanban Board

In parallel, a digital Kanban system was developed using Trello to manage the procurement process (Figure 5). When an ingredient reached its reorder point, its corresponding card was moved to the "For Buying" column. Once the order was placed, the card transitioned to "Coming" to monitor supplier lead time. Upon delivery and inspection, it was moved to "Received," and finally to "Ready," indicating full availability for use. This digital workflow provided transparency and control over the purchasing process of ingredients, while aligning with the physical system used in the kitchen.

Overall, the integration of the Kanban method with the previously established inventory control model translated simulation outputs into a practical, real-time management system. This implementation supported more efficient replenishment operations and contributed to improved reliability and responsiveness across the production process.

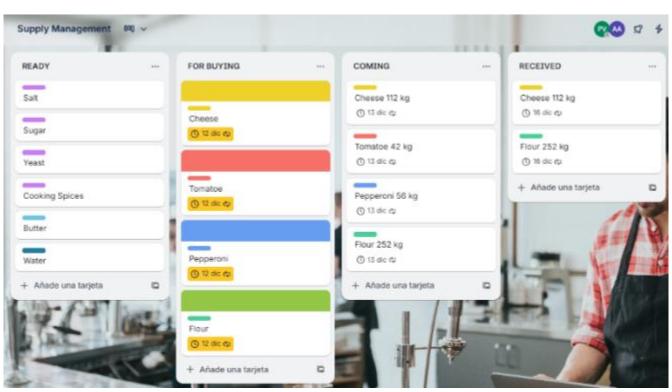

Fig. 5. Digital Kanban Board

As part of the intervention, two key tools were introduced to enhance operations at the assembly station: Standardized Work and Workstation Redesign. These efforts focused on reducing variability in how tasks are performed, improving the flow of the process, and optimizing operator movements to achieve greater operational stability. Before rolling out the changes on a larger scale, a pilot test was carried out to validate the new station layout and the standardized sequence of tasks. During this phase, tools, ingredients, and materials were arranged based on the proposed setup, and multiple observations were made to confirm task feasibility, operator comfort, and compliance with the defined standard times[1]. The results were encouraging, with a 99% compliance rate, it was confirmed that the new process was both repeatable and stable.

To further improve the assembly area, a new workstation layout was designed using DELMIA software, as shown in Figure 6. The goal was to organize tools and materials in a more ergonomic, and sequential way to streamline the workflow.

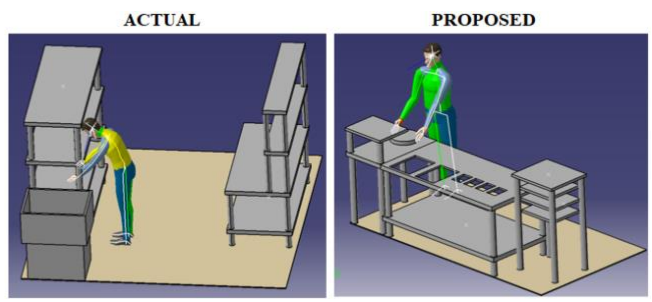

Fig. 6. Redesigned Table

In the original setup, operators had to move between scattered stations, which led to unnecessary fatigue, longer preparation times, and more process variability. By shifting to a straight-line layout from left to right, the operator's walking distance was reduced from 344 centimeters to just 55 centimeters, representing an 84% reduction. Additionally, the time spent moving dropped from 48 seconds to only 10 seconds, improving movement efficiency by 79% and contributing to a more stable and efficient workflow.

These changes are clearly illustrated in the spaghetti diagram in Figure 7, which shows the difference between the disorganized movement paths of the original layout and the smooth, sequential flow of the redesigned station. The analysis identified the assembly step as a key bottleneck in the original process due to excessive operator movement and non-value-added tasks. By redesigning the station and standardizing the work, the time required to complete this critical step was significantly reduced, which directly improved overall system performance. As a result, the total time to prepare a pizza dropped from 27.8 minutes in the original setup to 22.9 minutes in the improved model. This demonstrated that the benefits of the intervention extended beyond just the workstation level.

[1]Supplementary materials are available at: Standard Working Diagram.pdf

A crucial part of the redesign was the ergonomic assessment using the RULA method, which helped verify whether the new setup was physically appropriate for operators. Initially, the RULA results classified the task as high risk, indicating an urgent need for change. After implementing the redesign, the score improved to 2, which is considered acceptable. This represented a 71.4% reduction in ergonomic risk. Beyond improving safety, this reduction in physical strain also contributed to performance by minimizing task interruptions, improving posture, and making the work more sustainable over time. Integrating ergonomic analysis with standardized work proved essential not only for creating a safer workspace but also for supporting the broader goal of stabilizing and enhancing operational performance.

The integration of Forecasting Demand, the Kanban System, Standardized Work, and Ergonomic Redesign formed a comprehensive validation method, bridging analytical accuracy with operational effectiveness.

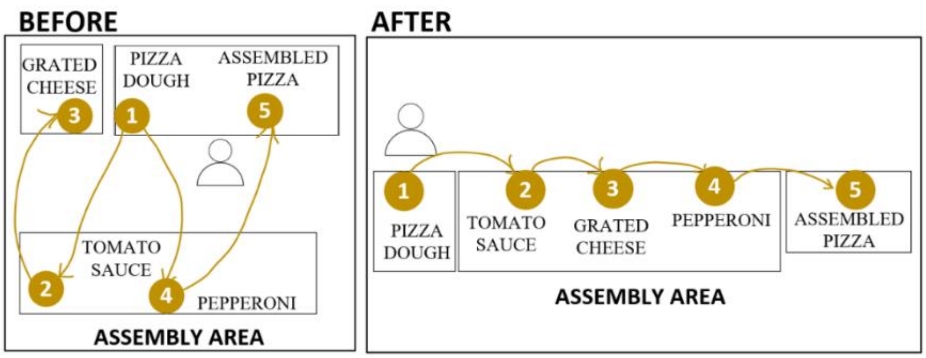

Fig. 7. Spaghetti diagram before and after implementations

C. *Simulation results*

Arena simulation software was used as part of a hybrid validation approach to evaluate the operational impact of implementing Lean Service tools, including Kanban-based inventory management, Standardized work and Workstation redesign. The developed model, described in Figure 9, represents the full restaurant workflow, from customer arrival to payment, including key internal processes such as order taking, pizza preparation, inventory handling, and final delivery to the customer.

To ensure realism and accuracy in the simulation, actual operational data from the restaurant was collected and combined with a detailed time study. This allowed for the definition of standard times for each process involved. These times were then analyzed using Arena's Input Analyzer to determine the most suitable statistical distributions. All distributions in Table 3 passed validation tests, and their parameters were used to simulate the “As Is” (current) and “To Be” (improved) scenarios.

The simulation results, summarized in Table 4, demonstrate significant improvements across all operational KPIs defined for this study. To ensure the statistical precision and reliability of these findings, 95% confidence intervals were computed and presented in brackets for both scenarios. These intervals were derived from a t-student distribution with 28 independent replications executed in Arena. This rigorous statistical approach confirms that the reported gains represent a stable performance range and are statistically significant, ensuring that the model's effectiveness is not due to stochastic variability but to the proposed systemic interventions.

Regarding service reliability, the On-Time Delivery Rate increased from 79.1% in the current model to 97% in the improved scenario, representing a 21.99% improvement. This change reflects enhanced coordination between kitchen operations and inventory management achieved through the integration of Random Forest demand forecasting and Kanban visual controls. Complementarily, the Stockout Rate fell from 11.46% to 6.25%, a remarkable 60.82% decrease that validates the precision of the predictive replenishment system. Furthermore, process efficiency showed substantial gains, with the Preparation Cycle Time dropping from 27.8 minutes to 22.9 minutes, a 17.63% reduction enabled by Standardized Work protocols that effectively minimized task variability during the pizza assembly phase.

TABLE III. VALIDATION RESULTS

Process	Distribution
Customer service time at table	UNIF (0.11, 0.271)
Order taking time	UNIF (1.16, 1.87)
Time to take order to kitchen and cashier	TRIA (0.15, 0.265, 0.38)
Search time for cheese, flour, tomato, and pepperoni	UNIF (0.75, 1)
Time to spread tomato sauce	UNIF (0.3, 0.59)
Time to add cheese	UNIF (0.3, 0.51)
Time to add pepperoni	UNIF (0.4, 0.77)
Pizza finished	UNIF (0.45, 0.6)
Time for checking supplies at the table	UNIF (0.5, 0.74)
Pizza baking time	TRIA (8.33, 8.99, 9.59)
Plating time	TRIA (0.07, 0.125, 0.15)
Pizza cutting time	TRIA (0.22, 0.329, 0.57)
Order dispatch time in kitchen	UNIF (1.39, 2)
Order delivery time	UNIF (0.45, 1)
Time spent in the dining room	UNIF (0.999, 3) +2*CantItems
Payment time	UNIF (0.08*CantItems, 0.32*CantItems)

In terms of internal efficiency, the Average Replenishment Time dropped sharply from 10 minutes to just 1.5 minutes, an 85% improvement through the introduction of a Kanban-based visual management system, minimized delays related to ingredient retrieval and communication between kitchen staff. The use of color-coded cards and centralized boards streamlined communication and reduced waiting times between preparation stages. Compliance with standardized times improved dramatically. In the original process, only 8.3% of tasks were completed within the expected timeframe. After implementing standardized work protocols, this figure rose to 99%, an increase of 91.62%. This improvement highlights the benefits of training operators in consistent task execution, as well as the role of visual aid and workstation reorganization in reducing variation.

Finally, the Cycle Time in Movements, which refers to the physical movement of operators within the kitchen, was reduced from 48 seconds to 10 seconds, representing a 79.17% decrease. This improvement was achieved through a redesigned workstation layout that reduced unnecessary movement, improved ergonomics, and organized tools and ingredients in a clear, sequential order. As a result, movement time was shortened, while operator comfort increased fatigue was reduced.

These results, validated by their respective confidence intervals, confirm that integrating Machine Learning for forecasting with Lean Service tools leads to a faster and more reliable service performance.

TABLE IV. INDICATOR RESULTS

Indicator	As Is	To Be	Variation	Original Model Results	Improved Model Results	Tools	Reference
On Time delivered	79.1%	97%	21.99% ↑	[72.7-85.5]	[93.4-99.7]	Machine Learning and Lean Service	[20]
Preparation Cycle Time	27.8 min	22.9 min	17.63% ↓	[25.5-30.1]	[20.6-25.2]	Machine Learning and Lean Service	[19]
Stock Out	11.46%	6.25%	60.82% ↓	[11.4-11.52]	[6.17-6.33]	Machine Learning	[31]
Average Replenishment Time	10 min	1.5 min	85% ↓	[9-11.1]	[1.3-1.7]	Kanban	[11, 7]
Compliance with Standard Process Time	8.3%	99%	91.62% ↑	[6.7-9.9]	[99.6-100]	Standard Work	[12]
Cycle Time in Movements	48 seg	10 seg	79.17% ↓	[47.6-48.6]	[10.8-11.04]	Station Redesign	[7, 30]

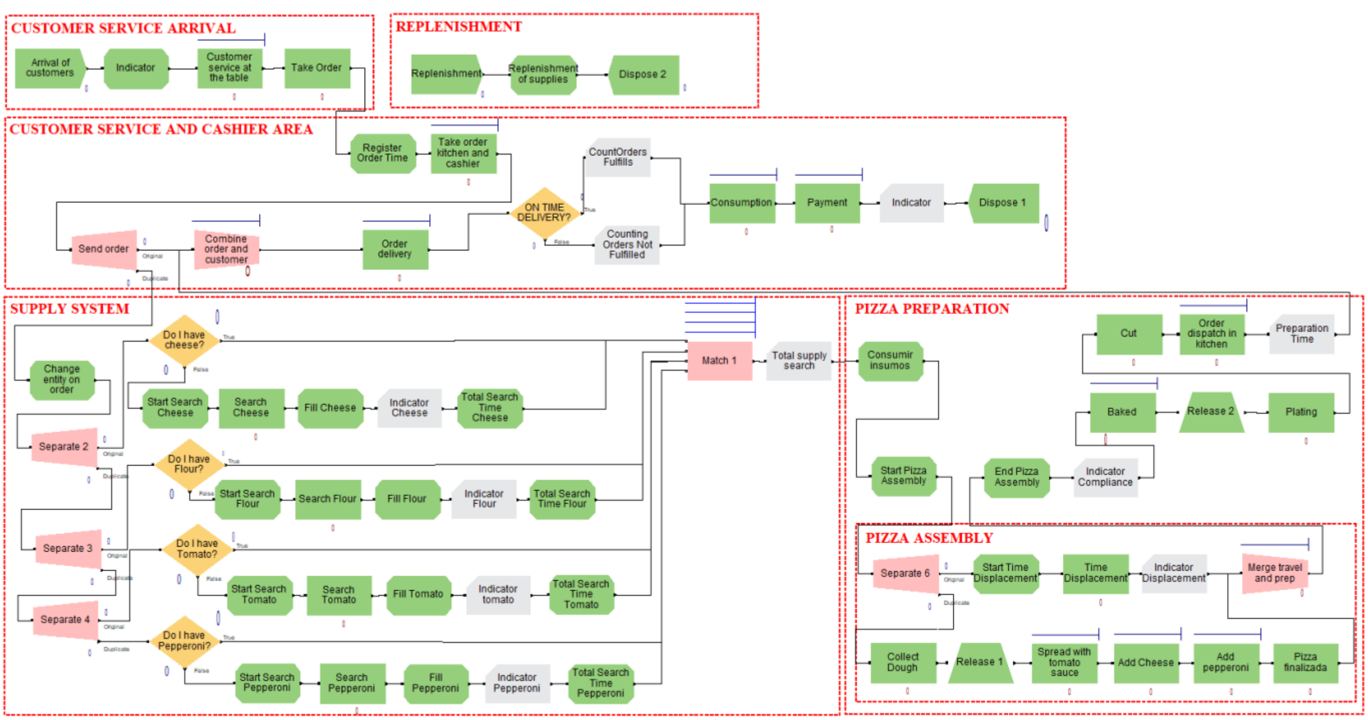

Fig. 8. Simulation of the proposed model

V. Discussion

These findings demonstrate the effectiveness of integrating machine learning, Lean logistics, and ergonomic redesign in assemble-to-order (ATO) restaurant environments, where operational flow depends on ingredient availability and process stability. The reduction in stock outs from 11.46% to 6.25% represents a 60.82% improvement, relevant to fast-paced service contexts. This result remains below the 75% improvement reported in [21], likely due to differences in supply chain control and environmental variability. However, it confirms that Lean and forecasting interventions improve system reliability.

Compared to [22], which reduced forecast error from 7.35% to 3.88%, this study achieved a lower error rate of 2.6%. Although this value is higher than the 1.9% reported in [20], it indicates consistent forecasting performance. These results show that machine learning models, particularly Random Forest, improve demand prediction in restaurant environments. Operational capacity increased from 57 to 80 pizzas per shift (40.35%), reflecting improved coordination of supply and production, consistent with findings in [17] related to throughput gains in ATO systems.

The implementation of a Kanban system reduced ingredient search time from 10 minutes to 1.5 minutes (85%). This result exceeds reductions reported in [11] and [7]. It reflects improved visual control and coordination of replenishment and layout design. Compliance with standardized work increased from 8.3% to 99%, exceeding the 82% reported in [12]. Establishing a preparation time of 3 minutes improved performance compared to the 4.5 minutes reported in [17].

These adjustments, in conjunction with the redesigning of the workstations, helped reduce total preparation time by 17.6%, bringing it down from 27.8 to 22.9 minutes, like [16, 19] found in his study. On the ergonomic side, the results were also positive: the RULA score, measured through DELMIA, dropped from 7 to 2, meaning a 71.4% decrease in physical strain. This is comparable to the improvements reported by [18] (75%) and [23] (60%). Beyond that, the new layout led to a major reduction in movement-related cycle time, falling from 48 to just 10 seconds, a 79.17% improvement. This surpasses the 29% reduction in travel time and distance reported by [7], and the 25.4% distance reduction achieved by [24], showing how effective thoughtful spatial design can be, even in small-scale setups. Overall, these improvements increased the On-Time Delivery rate to 97%, exceeding the 90% benchmark reported in [20]. This confirms that integrating Lean tools and machine learning improves service reliability in high-variability restaurant environments.

Despite these results, several limitations must be addressed to ensure scalability. First, transitioning the model to larger restaurant franchises may introduce scalability constraints, as manual visual controls require digital integration to maintain operational efficiency. It is important because the standardized process enables the consistent definition of steps, as the company operates with standardized products. Second, seasonal demand variability affects model performance, as it depends on a 116-week historical dataset. External market shocks may impact forecasting accuracy. Finally, system reliability depends on data quality and requires digital infrastructure to sustain forecasting and replenishment performance.

A. *Economic Validation*

The financial analysis of the project considered a 12-month horizon, with a total estimated investment of 2,660 PEN is justified by focusing on intangible assets instead of physical infrastructure. A 9.47% discount rate (COK) was used, based on the CAPM model. To evaluate the proposal's profitability, key financial metrics were calculated: Net Present Value (NPV), Internal Rate of Return (IRR), Benefit-Cost Ratio (BCR), and Payback Period. According to Table 5, the results were highly favorable. The project achieved an NPV of 73,398.88 PEN and an IRR of 307%, far exceeding typical investment thresholds. The BCR stood at 34.16, indicating that each PEN invested generated 34.16 PEN in return. Additionally, the investment was recovered in just 5 months and 11 days, confirming the proposal's strong economic performance and short-term impact.

TABLE V. Validation Results

Indicator	Value
NPV	73,398.88
IRR	307%
BCR	34.16
Payback	5 months and 11 days

VI. Conclusion and Recommendations

This study addresses low on time delivery performance in an assembly to order restaurant environment affected by demand variability and supply constraints. The integration of Lean Service and Supply management improved key operational indicators, including an 85% reduction in search time, 79% reduction in movement time, 71% reduction in ergonomic risk, and 61% reduction in stockouts. The forecasting model achieved a 2.6% error rate and the On-Time Delivery rate increased from 79.1% to 97%.

Although the results are promising, the study was conducted in a single context over a limited period. Future research should evaluate the model in other environments and over longer periods. Additional technologies such as real time tracking and adaptive planning could further improve performance.

In short, this research shows that integrating Lean tools with data based decision making improves service reliability in dynamic environments, offering a useful and adaptable path for similar operations.

References

[1] Grand View Research, "Foodservice market size, share & trends analysis report by type (full-service restaurants, quick service restaurants, cafes & bars), by region, and segment forecasts, 2024–2030," Grand View Research, 2024.

[2] Organización Mundial del Turismo, "Tourism highlights 2023," UNWTO, 2023.

[3] KPMG, "Food & beverage industry outlook in Latin America," KPMG, 2023.

[4] Ministerio de la Producción del Perú, "Informe anual de la producción nacional 2024," Ministerio de la Producción, Lima, Peru, 2024.

[5] Instituto Nacional de Estadística e Informática, "Informe técnico: Producción nacional, marzo 2024," INEI, Lima, Peru, 2024.

[6] B. E. Braúl Oviedo and E. C. Ruiz, "Systematic review of improvement methodologies for production management optimization in the restaurant sector," *Ingeniería y Competitividad*, vol. 26, no. 3, 2024.

[7] L. Casallo, E. Lucero, F. Maradiegue, E. Marcelo, and J. C. Alvarez, "Application of mixed methodologies in the production planning of screw conveyors for the flour and pasta food industry," *International Journal of Engineering Trends and Technology*, vol. 70, no. 8, pp. 435–446, 2022.

[8] M. Rodrigues, V. Miguéis, S. Freitas, and T. Machado, "Machine learning models for short-term demand forecasting in food catering services: A solution to reduce food waste," *Journal of Cleaner Production*, vol. 435, Art. no. 140265, 2024.

[9] V. L. Miguéis, A. Pereira, J. Pereira, and G. Figueira, "Reducing fresh fish waste while ensuring availability: Demand forecast using censored data and machine learning," *Journal of Cleaner Production*, vol. 359, Art. no. 131852, 2022.

[10] G. Loyola-Ferrer, W. F. Veldi-Díaz, and J. C. Quiroz-Flores, "Enhancing service levels in a Peruvian beverage SME: An innovative model integrating machine learning and 5S methodology," *International Journal of Engineering Trends and Technology*, vol. 73, no. 3, pp. 561–580, 2025.

[11] R. T. Salunkhe, G. S. Kamble, and P. Malage, "Inventory control and spare part management through 5S, Kanban and Kaizen at ABC industry," in *Proc. Second Int. Conf. Emerging Trends in Engineering (SICETE)*, Jaysingpur, India, 2013, pp. 43–47.

[12] C. Perez-Canchanya, M. Urbina-Suarez, and A. Flores-Perez, "Improvement model to increase the order fulfillment rate in a Peruvian SME food company using SMED, Kanban and standard work," *Advances in Transdisciplinary Engineering, IOS Press*, 2023.

[13] C. A. Sathe and C. Panse, "An empirical study on impact of project management constraints in agile software development: Multigroup analysis between Scrum and Kanban," *Brazilian Journal of Operations & Production Management*, vol. 20, no. 3, Art. no. 1796, 2023.

[14] G. L. Medina Medina et al., "Improvement in the supply chain of restaurants in Lima through the synergy of lean tools and system dynamics," *Proceedings of the 22nd LACCEI International Multi-Conference for Engineering, Education and Technology*, 2024.

[15] M. Briceno-Pinheiro, N. E. Torrico-Menacho, and A. Flores-Perez, "Service management model based on standardization, SLP and 5S to improve the NPS in SMEs in the service sector," *International Conference on Industrial Engineering and Applications*, pp. 41–46, 2023.

[16] C. A.-T. Millones, J. C. Quiroz-Flores, and Nallusamy, "Enhancement of productivity and efficiency through a service model with lean service tools – Case study," *International Journal of Mechanical Engineering*, vol. 10, no. 9, pp. 18–30, 2023.

[17] A. Onaga-Nishimura et al., "Service management model based on lean service and systematic layout planning for the improvement of customer satisfaction in an SME in the restaurant sector in Peru," *International Conference on Industrial and Business Engineering*, 2022.

[18] C. S. García, A. C. Marroquín, I. A. Macassi, and J. C. Alvarez, "Application of working method and ergonomic to optimize the packaging process in an asparagus industry," *International Journal of Engineering Trends and Technology*, vol. 69, no. 9, pp. 14–23, 2021.

[19] G. M. Mejia-Sanchez, R. E. Del Valle-Cevallos, and A. Flores-Perez, "Improvement model applying Holt-Winters and 7's method to reduce waste and production time in the Peruvian gastronomic sector," *Proceedings of the CONIITI*, pp. 1–5, 2024.

[20] D. S. Canales-Huaman, K. G. Gamio-Valdivia, and J. C. Quiroz-Flores, "Integrated lean logistics-warehousing model to reduce lead time in an SME of food sector: Research in Peru," *Proceedings of the 3rd International Conference on Industrial Engineering and Industrial Management*, pp. 182–188, 2022.

[21] A. F. Montes-Cabrera, F. Gherardi-Jimenez, and J. C. Quiroz-Flores, "Enhancing service efficiency in Peruvian automotive workshops through the integration of SMED, Kanban, and TPM," *International Journal of Engineering Trends and Technology*, vol. 73, no. 5, pp. 148–160, 2025.

[22] K. A. Carbajal-Vásquez, R. A. Piscoya-Alvites, J. C. Quiroz-Flores, Y. García-Lopez, and Nallusamy, "Minimization of smashed products in sustenance industries by lean and machine learning tools," *International Journal of Mechanical Engineering*, vol. 10, no. 10, pp. 12–26, 2023.

[23] D. Aquino, E. Rodríguez, and J. C. Quiroz-Flores, "Ergonomic redesign model to reduce musculoskeletal disorders in a cluster of SMEs in the clothing accessories sector," *Proceedings of the 20th LACCEI International Multi-Conference for Engineering, Education and Technology (LACCEI 2022)*, 2022.

[24] J. Avalos-Maldonado, E. Mezarina-Azaña, and J. C. Quiroz-Flores, "Lean service management model to reduce canceled orders in a fast-food company," *Proceedings of the 2nd LACCEI International Multiconference on Entrepreneurship, Innovation and Regional Development*, 2022.